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INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION

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ANNUAL REPORT OF THE INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION FOR 1944

PART I. DIRECTOR'S REPORT

During 1944 we continued all phases of the war-time program of research which was formulated in 1942. This program included studies aimed specifically at developing methods and procedures for correcting unsatisfactory range-watershed conditions on the national forests. It also included continued efforts on analysis and publication of accumulated research data covering other phases of wildland management, on post-war planning, and on the maintenance of a few long-range study projects.

This program proved to be highly fruitful from the standpoint of results of immediate usefulness as well as in clarifying the needs for further research. An appraisal of what is believed are the major station-wide accomplishments and needs is supplemented in Part II by additional detail concerning divisional activities and plans.

Assistance to Region Four

"Correcting unsatisfactory range-watershed conditions on the national forests" in Region 4 means first being able to determine more accurately condition and trend of the range and, second, inauguration of a program that will bring into adjustment numbers of livestock grazed and requirements of the plant and soil mantle. A survey of this problem made it readily evident that the Station, because of its past research and the experience of its men, was best prepared to help on two particular phases: (1) Developing better techniques and methods for determining condition and trend on the range watersheds that could be used by Administration in the analyses of the range and evaluation of the management job, and (2) in furnishing information and giving guidance to the task of increasing forage production through sagebrush eradication and artificial reseeding.

Personnel from both the divisions of Range Investigations and Influences were assigned to these jobs. A. R. Croft of the division of Influences and Lincoln Ellison, summer range studies, spent most of the year on the condition and trend project. Bailey, Stewart, and Craddock also gave considerable time and thought to the furtherance of this work. Hull, Robertson, Plummer, and Pechanec worked on the sagebrush eradication and artificial reseeding phases of range rehabilitation. Not only was considerable time spent in field work, in compilation of data, in writing

manuscripts for publication, and in preparation of instructions and forms, but also in training Administration personnel in the meaning and the use of the informational material.

Condition and Trend

Research Paper No. 6, "Principles and Indicators for Judging Condition and Trend of High Range Watersheds," by Ellison and Croft was prepared during the winter of 1943-44, and distributed to all supervisors and rangers in Region 4 accompanied by a request from the Regional Forester that the bulletin be studied carefully and tested in the field to determine its applicability to the problem of determining condition and trend. Replies to this indicated a general acceptance of the methods and techniques presented and a conviction that, if followed, they would contribute much to a more accurate determination of condition and trend of ranges.

Work in 1944 consisted principally of testing critically in the field principles and indicators which we had previously set up and in formulation of a procedure with forms and guides for use by range inspectors. Supervisors and regional staff men contributed much to the development of the procedure by trying out a trial method in the field and offering suggestions for its improvement.

To further the use of the procedure developed for determining condition and trend, field conferences were held with about half the supervisors and most of the regional office inspectors during which the principles underlying the procedures were analyzed and discussed, and practice was given in the use of the technique itself. Training courses will be conducted next spring for the remainder of the supervisors and certain key rangers.

Importance of Knowing Condition and Trend

After our experience with range managers on a number of different forests in the Region, our belief in the importance of being able to read the range was greatly fortified. We were all able to agree that to be able to determine condition and trend of a range is fundamental in range management.

Knowledge of condition is essential in determining grazing capacity and in planning the use of range. Knowledge of trends is the principal means whereby the results of a management program such as adjustments in number, in season of use, etc., can be ascertained. Determination of trend is telling whether the range condition is being maintained, is improving, or is deteriorating. In management of mountain range lands, no other accomplishment is so essential as being able to recognize early, changes taking place in vegetation and soil on range-watershed slopes.

Sufficient Knowledge Has Been Lacking

Judging condition and trend of the range has been an activity of range men since early in the history of range use in this country. Success

accompanying this endeavor has not been full. Many of the mistakes made in the management of range-watershed land and many of the problems, both in conservation and public relations, that today confront livestock men and water users as well as the agencies responsible for managing public lands are due in no small degree to deficiencies in an understanding of the facts and principles involved in determining condition and trend and in the methods and techniques used for their determination.

That we lack adequate understanding is borne out by the contradictory pronouncements of range condition and trends on large range areas in general, together with the inconsistencies of periodic inspection reports covering the same ranges. Even more significant is the fact that stocking on many ranges has been reduced time and again only to require further reductions when at a later period it was found that the range was still deteriorating. And in all too many cases deterioration of watersheds has not been recognized until the soil mantle has become severely eroded and floods have issued from the canyons.

What Do We Mean by Range Condition and Trend?

Range condition is range health. More specifically, it is the condition of the plant cover and the soil mantle in relation to a standard set up by management objectives and thus provides a basis for determining the extent to which a site has been damaged by use. For range watershed lands the management objective is maximum sustained forage production and maximum usable water yield. The plant cover standard for achieving these dual objectives may differ greatly between ranges and usually will be different than the original plant cover. For the soil, however, there can be but one standard and that is stability. The necessity for maintaining the soil regardless of the kind of plant cover desired should be evident. Moreover, experience and research have shown that soil stability will not only meet the requirements for critical forage production but is also essential for desirable streamflow.

Range trend is change away from or toward a desirable condition. In addition to direction, range trend has aspects of velocity and selectivity. The rate of change may be rapid or slow, thus defining velocity. It may be selective such as when soil stability is maintained while at the same time plant composition changes, or it may involve concurrent change in both soil and plants in the same or in opposite directions. The basis for determining trend must, of course, be an understanding of what has happened and what can happen on each site.

What Factors Are Involved?

To be able to determine condition and trend it is essential to understand what is meant by the range. It is not just grass or even forage, but a complex composed of climate, local and general, of topography with aspects and varying degrees of slope, of soils, of vegetation, and of animals. These are not independent components but rather interrelated and interdependent and together constitute the range. We know that under natural

conditions the soils on many sites acquire a balance between the forces of degradation which tend to tear down and the forces of aggradation which tend to build up. Moreover, we know that this balance or relationship may be upset by changes in any one of the components of the complex and thus set in motion a whole series of events that may be most difficult to recognize or control.

Mountain ranges are more variable than other kinds of range. Great differences in climate, aspect, degree of slope, infiltration capacity, and erosion potential as well as in vegetation occur within small units of range. Add to this complicated system a short growing season, grazing during the growing season, and the inevitable differences in livestock distribution and forage utilization--then only can we begin to appreciate the true nature of the work and the task of determining condition and trend.

What are Essentials of Procedure?

Determining condition and trend is reading the range. The basis of the procedure is the theorem that what has happened to the range in the past and the changes now occurring are recorded in the soil, in the vegetation, in the regimen of the streams, in stream channels, and in the material carried and deposited by streams. These records of change are to be recognized by certains signs, indicators, or criteria. Changes in stream regimen, increased flood flows and deposition, accelerated erosion and sedimentation, although essential to a full understanding of changes that are taking place on the range watershed, are the results of changes in the soil and plants of the watershed slopes that have been in progress for a considerable time. These main channel and downstream changes are indicators of advanced stages in range-watershed deterioration, and to prevent their occurrence careful observations must be made periodically of the plant cover and soil mantle in order to recognize any sign of early deterioration.

Because the range which we are attempting to read is made up of so many different interacting parts or elements, it follows that the procedures for recognizing change must provide for critical local observations of many features and extension of judgment to larger areas. There is no simple tool, gadget, or single indicator which will give us an adequate diagnosis of the changes that are occurring. All the evidence must be observed and considered before we can be sure of the condition of the soil and vegetation in relation to our predetermined standard, and if change is taking place, the direction and velocity of that change. Many errors of the past have been due to working with too few indicators or overemphasizing the importance of a single indicator.

Indicators used in the past have been restricted pretty largely to plants. Although essential in any procedure for determining condition and trend of ranges, plants alone are not enough. If range men have been conscious of the importance of soil stability in the range complex it is quite evident that frequently they were unable either to recognize changes that were

taking place in the soil or to evaluate such changes. It has been a common practice to base judgment of condition and trend on current utilization of forage alone or on the stage of plant succession which a species or group of species was thought to denote. It was reasoned that if utilization is so regulated that only a certain percent of the so-called "key species" is taken by the end of the grazing season, the range is in good condition and will remain so as long as the amount of the plant or plants taken does not exceed the designated volume.

A critical reexamination of certain sites, giving attention to multiple factors including soil stability, brought to light the fact that ranges considered to be in good condition because "key grasses" were being grazed no more than was allowable according to the utilization tables were in reality rapidly deteriorating. Soil erosion was progressing at such a rate that forage species were being reduced in vigor and density more by the action of erosion than by grazing. The point is this: because of the great variability of sites in mountain ranges proper use factors cannot be assigned to the various forage species that will enable the manager to use them alone in determining grazing response. Proper use factors and key species are valuable only if the are derived from a sound ecologic understanding of the area and even then they must be used in conjunction with other evidence such as is associated with the soil.

Holding inflexibly to the concept that the occurrence of a species or a group of species considered to be typical of the climax denotes satisfactory condition or improvement in condition has led in many cases to wrong conclusions. It is a fact verified by numerous observations that on actively eroding soil, even in advanced stages of erosion, climax plant species rather than species of a lower successional stage may dominate a site. However, plant succession and current utilization are essential concepts and as we learn more about them their value will increase as indicators in determining condition and trend of ranges, but they cannot be used alone or emphasized to a degree that they exclude the significance of other evidence.

No doubt an important reason for the tendency to limit observation to plant indicators in range studies is lack of appreciation for other evidence. We have been less concerned about indicators that denote soil changes or soil stability, and without adequate usable knowledge of soil factors the administrator naturally tends to restrict his observations to evidence with which he is most familiar. When knowledge is limited to a part of the range complex, there is danger of giving meaning to the presence or absence of an indicator that would not be justified if more of the facts were at hand. For instance, we have all come to recognize gully erosion and to fairly well evaluate its significance. However, if we are not familiar with the various manifestations of soil deterioration, the absence of gullies might lead to the conclusion that erosion is not occurring or if occurring is not serious. Such a conclusion may be entirely false for we are learning that erosion, even severe erosion, may occur under certain conditions of soil and climate without the formation of gullies.

Procedures and techniques for determining condition and trend should give emphasis to observation and consideration of all evidence and to using the evidence in reaching conclusions. Only then will they serve adequately in arriving at a reasonably accurate judgment of condition and trend of a range.

Details of procedure are beyond the scope of this report. As a minimum in requirements, it seems these procedures must allow for adequate coverage of the range. They must provide a simple means of summing spot judgments into an over-all conclusion regarding a large area. They should stress the need for recording all observations in such a manner as to be conveniently available for future reference. The details should be arranged so that judgments are clearly set apart from measurable facts. They must provide for suitable follow-up action.

Deficiencies in Knowledge

A sharp realization of our greatest needs and deficiencies in knowledge essential to the development of a more satisfactory system of range inspection has come from efforts to set up techniques and procedures for determining condition and trend of range watersheds. What is needed most is to be able to recognize at a much earlier stage changes that are occurring in the plant and soil mantle. This must be done through better adaptation of information already acquired in ecology, utilization, erosion, and acquisition of new knowledge.

Much of our information, obtained from studies of range-watershed lands, falls short of direct application to judging condition and trend because it was gathered primarily for other purposes, but also because it has been possible on only a relatively few of the diverse sites of a mountain range to measure accurately by means of plots and pastures the effects of grazing practices on the vegetation, soils, and infiltration of precipitation. However, basic data that have been obtained on a limited number of plots can be made to serve by relating them to observable evidence in the plant cover and soil mantle and by extending the results of this synthesis to other parts of the range.

In addition to adapting knowledge already acquired from past research to the problems at hand, a great deal more basic information is needed in the fields of soils and plant ecology before we can do an entirely satisfactory job on many of our ranges.

More Knowledge of Mountain Soils Is Needed

Of all the important factors and elements making up the range complex we probably know least about the soil. As yet a science of watershed soil has not been developed. It is axiomatic that the first objective in range management on steep mountain lands must be soil stability, and in order to make sure that mountain soils under grazing use will be maintained or that stability if lost through past grazing will be reestablished, we must learn more about the properties and functions of these soils. Our knowledge

of the effects grazing of the forage and trampling of the soil have on soil stability, on the soil's capacity to infiltrate rain and snow melt, and the reproduction of plant species must be fuller and more specific. And also we must learn to recognize the manifestations of these effects. Requirements of the job of making range-watershed inventories and recognizing adequately effects of use on the range complex dictates that we learn to evaluate by inspection:

1. Relative infiltration capacity of the soil.

2. Potential productivity of the soil. (To know this will enable the manager to judge not only what the site is capable of producing but also the extent to which production has declined.)

3. Susceptibility of soil in various classes and conditions to disturbance by trampling and grazing.

4. Changes, both advanced and incipient, that have occurred or are now occurring in the soil due to use, such as leaching of the plant food, sheet washing, and shoestring gullying, and determine what these changes mean in terms of productivity, infiltration capacity, and stability.

Consideration of only one of these fields of inquiry, "relative infiltration capacity of the soil," will serve to illustrate the soil problem. The rate at which a soil will infiltrate rain and snow melt defines pretty much the problem of soil stability on steeply sloping lands. It determines largely whether or not there will be surface run-off, and how much will occur, and surface run-off in turn is the major factor in soil erosion.

There are large normal differences in infiltration capacity between soils of different sites, but also there are large differences due to modification of the soil and the plant mantle through use. It is well known that within the same drainage one site normally will be capable of infiltrating all of the precipitation from a summer storm while another permits a large part of the rainfall to discharge over its surface. Obviously, these two contrasting sites cannot stand up under the same degree of livestock grazing. On the other hand, undisturbed soils that were capable of infiltrating precipitation at the rate of several inches per hour are known to have been so modified by grazing and trampling that their capacity for infiltration has been reduced to only a fraction of their original capacity. Conversely, infiltration capacities of deteriorated sites have been increased severalfold through improved range and livestock management practices.

The manager must be able to recognize these inherent differences in infiltration capacities between sites and, in addition, detect changes in the soil and plant mantle sufficiently early so as to prevent accelerated run-off and erosion. The question facing the investigator is: what are the features or properties of the soil that can be recognized by the

inspector which reveal these infiltration characteristics? The answer no doubt lies in gathering more facts, in analysis and in synthesis. Before infiltration capacities of the soils can be determined by inspection, measurements by means of infiltrometers or run-off plots of the different soil types and conditions must be made and relations established between infiltration rates and recognizable soil characteristics.

There is no question in our minds as to the position this class of studies should occupy in the schedule of research priorities at the Intermountain Forest and Range Experiment Station. However, available funds will make possible only a modest beginning.

Ecologic Knowledge

Application of ecological principles is a basic procedure in determining the health of the range and its trend. The individual plant species together with the community in which it grows reflects many of the changes, both in the plants and the soil, that are taking place due to grazing. However, before we will be able to recognize these essential changes, considerably more must be known of the ecology of mountain range lands and of the relationship of species and groups of species to erosion, grazing, climate, microclimate, and slope. A job of much importance and needing to be undertaken at the earliest possible season is a systematic working out of the ecology of the major plant types on our watershed lands. Failure to have a sound ecological foundation has resulted in faulty selection of "key species" in setting up of proper use factors without regard to slope, soil exposure, soil disturbance, or the possibility of invasion of inferior species and of thinking of management too largely in terms of individual plants rather than of a community of plants. When deterioration of both the plants and the soil in these mountain types has occurred, this job in ecology is fraught with considerable difficulty.

The general concept of plant succession has become well established in ecological procedure. However, care must be taken in applying the standard succession stages to a range where soil and plants are being modified by the grazing of livestock. Plant sequences in retrogression under grazing may be altogether different from what downward succession would be due to natural causes such as long-time trends in climate. Likewise, natural revegetation of a depleted range, with or without grazing, may have a much different sequence of species than the upward succession that originally took place while the original soil and plant cover were being formed.

Not only is it likely that succession stages in the process of revegetation of denuded ranges will be different than is provided for in the general successional concept, but it will be different on different ranges because they will exhibit various degrees of deterioration. The nature of the succession will be determined not only by the climate, the dominant factor in succession under natural conditions, but also the "local climate," the extent to which the topsoil has been removed by erosion, the level to which plant deterioration has descended, the availability of seed, and the nature of the grazing to which the area is

subjected. The complexity of the succession problem on mountain ranges grazed by livestock accents the need for careful detailed ecological studies and warns against broad generalizations if species and plant societies are to be used by the range inspector in determining the condition and trend of the range.

The Intermountain Station plans to begin a systematic study of the ecology of the region. Its first efforts will be concentrated on the Wasatch Plateau in Utah.

Correcting Unsatisfactory Watershed Conditions by Sagebrush Eradication and Reseeding

Involved in the job of correcting unsatisfactory range conditions is reduction in numbers of livestock and in some cases total exclusion. Reduction in numbers of livestock using the ranges of the national forests will have important economic and social implications. There is no surplus range in the region and no surplus harvested feed supply to which these animals could be shifted. Therefore, if national forest reductions are made without increasing the forage supply on some of the depleted but potentially productive ranges, livestock populations in the Intermountain region will have to be seriously reduced. But reduction and even total exclusion of livestock will not in all cases result in stabilization of the soil and in renewal of the plant cover. Erosion has attained such momentum on some areas that even with total protection it will continue--even to the point of removing all topsoil. Large areas of potentially productive range lands, especially in the aspen zone of the Intermountain region, have been so completely denuded of forage species that the time required for natural recovery due to lack of seed source will be intolerably long.

Large areas of sagebrush land, principally in the spring-fall grazing zone and also occupying considerable area in the lower parts of the summer range, are producing only a fraction of the volume of forage they formerly did because of overgrazing and of thickening up of the sagebrush stand. A considerable acreage of these lands will not revegetate to forage plants because of the lack of seed and the restrictive competition set up by the dense stands of sagebrush. Aid must be given this land through sagebrush eradication and reseeding.

Not only can sagebrush eradication and reseeding be applied to check erosion and rehabilitate the plant cover, but it can be employed to greatly increase the forage supply, even to the point of not only taking care of reductions necessary on the national forests but, in addition, actually making it possible to increase the number of livestock in the region.

Sagebrush Eradication and Reseeding

Studies in sagebrush eradication and reseeding have progressed far enough to enable us to set up specifications for greatly increasing forage

production of millions of acres of sagebrush lands in the Intermountain region. Furthermore, the validity of these research findings has been demonstrated by large scale trials and demonstrations made possible through cooperation of the Grazing Service and the national forests and private range land owners. This information has been made available to range administrators, range livestock operators, farmers, and the public in general through preparation and distribution of bulletins, pamphlets, articles in livestock journals, and in lectures. In addition, much time has been spent with the national forest administration, the Grazing Service, the AAA, and private operators in giving advice and counsel. The demand for information has exhausted some of our publications and requests for help on actual operations have been greater than we could fill.

Notwithstanding the progress of research, accomplishment of the total revegetation job is not likely in the near future because of the lack of funds, labor, and equipment and because the land needing revegetating is in several ownerships. The amount of work the national forests could accomplish, even with ample funds, is limited by range land ownership pattern. However, in order that the maximum acreage of sagebrush lands be brought into forage production with whatever funds are available, care and study should be made to employ for each range site treated the most economic and efficient method that has been given the test of research and experience.

Prescribed Burning Is a Possible Solution

Plowing, railing, and fire have proved to be effective in sagebrush eradication, and each has its place in the program. However, while public agencies readily accept use of the plow and rail, they are reluctant to employ fire which, for certain ranges, is most efficient and economical. This attitude is understandable when one realizes the long struggle that has been made against forest and range fires which, for the most part, have been destructive. We have in fire, however, a tool which if used on the right lands and in the proper manner, meets the requirements of efficiency and low cost for sagebrush eradication. With it thousands of acres of brush land, some of which are within the national forests, can be transformed into productive ranges without the application of other cultural treatments. These lands have sufficient understory of grasses which will increase in density and volume several fold as the result of the release afforded by the elimination of the sagebrush. Also fire can at a fraction of the cost of plowing or railing be used to eliminate the sagebrush on other thousands of acres of range land which, because of insufficient understory of grasses, will have to be reseeded following sagebrush removal.

Even though prescribed burning is restricted to the type of range which research and large-scale practices have demonstrated can be burned safely, the use of fire can overcome many of the current limitations of money and man power. Fire can be used to help produce feed on deteriorated valley lands and thus help absorb the necessary reductions of livestock on the more critical mountain areas.

More Reseeding Research Is Needed

From the standpoint of watershed protection, the vegetal types above the sagebrush zone on the national forests are most critical so far as management is concerned. Here most of the overgrazing is occurring, erosion is most serious, and here reduction in livestock numbers must be made. Only in one of these zones, the aspen, have we obtained sufficient reliable information to justify large-scale programs of reseeding, and even here a more rapid and less expensive method of seed dissemination must be developed. Reseeding methods for other upland zones, however, are still in the pioneer stage.

Headwater, weedy, and eroding "sore spots" which are the source of destructive run-off and sediment, present a most difficult problem of artificial revegetation. Successful reseeding has been attained on some of these areas by eliminating run-off and soil erosion through the construction of terrace trenches and reseeding. But this is a much too expensive method for treating all but a few of the most critical watershed areas. Less expensive methods are needed.

We are well aware of the problem here and the difficulties which face the investigator and, with most of the reseeding methods for improving sagebrush-wheatgrass lands fairly well established, investigations now can be initiated in the vegetative types farther up the mountain.

Much more work needs also to be done in the field of developing and improving brush eradication and reseeding equipment. Practically all equipment used at the present time was designed for rockless, flat-lying farmland and they have proved to have many limitations when used on range lands that are steep, rocky, or covered with heavy brush. No doubt ease of operation can be greatly increased and cost reduced by using equipment such as drills, drags, plows, etc., that are especially designed and constructed for use on range lands.

Other Work of the Station

Although most of our efforts during the year were spent in working out methods and techniques for the determination of condition and trend on range watersheds and in supplying information on sagebrush eradication and reseeding through publications and personal contacts, accomplishments were made in other phases of our investigations program. Details of work on the various projects are outlined in separate reports prepared by the division chiefs. There are, however, certain problems and accomplishments connected with these projects which I wish to discuss here.

Management of Crested Wheatgrass Ranges

Another problem that calls for immediate expansion of our research program is the maintenance of the large acreage of reseeded grass range. During the past five years several hundred thousand acres of range lands

have been seeded to grasses, principally crested wheatgrass, and plans for the immediate future propose the seeding of several million additional acres.

Range land reseeded to crested wheatgrass gives promise of becoming an important element in the range livestock industry. However, little is known about the grazing resistance of these grasses or the management practices that must be employed to maintain forage production and stability of soil. Already some of the crested wheatgrass ranges are showing marks of deterioration, as evidenced by reduction in vigor of the plants, invasion of cheatgrass into the stand, and by early stages of accelerated erosion. A research program should be gotten under way that will give us at the earliest possible time the basic information upon which management plans can be developed that will assure the safe grazing of these newly created ranges.

A beginning on these important investigations has been made cooperatively with the Bureau of Plant Industry, Soils, and Agricultural Engineering, the Soil Conservation Service, and the Utah Agricultural Experiment Station at Benmore, Utah where fairly adequate physical facilities have been installed for carrying on the research, but present funds are insufficient to properly man the project.

Cheatgrass--A Major Problem on Spring-Fall Ranges

Whatever phase of the spring-fall range problem we attempt to investigate, whether it be management, sagebrush eradication, or reseeding, we eventually are confronted with the annual downy bromegrass (Bromus tectorum). It has become apparent that the solution to the spring-fall range problems will never be found until we understand more fully the characteristics of this annual grass.

Downy brome, or cheatgrass as it is commonly called, is an aggressive annual native to Europe which was introduced into the Intermountain region in about 1900. It has since spread over tens of millions of acres of range lands in southern Idaho, Utah, and Nevada. With accidental fires and range misuse it is still on the march, occupying new ranges in the valleys and extending up the mountains into the timber types. On most of the Idaho spring-fall ranges, range management is essentially cheatgrass management, because it makes up more than 50 percent of the feed taken by livestock.

Most technical range men feel that cheatgrass, because it is an annual and is occupying space which once supported native perennial plants, should be eliminated. However, this grass is furnishing more than half of the forage on the spring-fall range lands in southern Idaho and an appreciable amount in Utah and Nevada. On many ranges it is practically the only forage plant left and it is doing yeoman service in holding the soil. Although it is important as a forage it is recognized that cheatgrass fluctuates in volume very much more than do native perennials. Also, it dries out early creating a fire hazard throughout the summer;

in fact, it is the No. 1 fire problem in the region. If it should be found best for the livestock industry, soil conservation, and fire protection to replace this annual with perennial grasses, the question of methods and practicability immediately arises. Can this be done by management alone or must a reseeding program be undertaken? If management can do it, what system must be followed? Will the time involved outweigh the advantages of conversion? On the other hand, if cheatgrass is to remain a dominant forage on certain ranges what management practices must be followed to assure maximum yield and protection of the soil?

Conversion of cheatgrass stands by reseeding poses a major problem. Very little success has followed seeding directly in the stand. A successful method will probably have to provide for an effective method of reducing competition for soil moisture.

From this brief discussion of cheatgrass on our spring-fall ranges, it becomes readily apparent that the many essential questions can be answered only through a program of intensive research. A problem analysis of cheatgrass on the spring-fall ranges in southern Idaho has been made by Hull and Pechanec and a rough draft manuscript prepared. The need now is for funds with which to undertake research of some of these important problems.

Watershed Management and the Irrigation Enterprise

The national forests of the Intermountain region yield 80 percent or more of the water upon which agriculture and much of the industry of the region depend. This water by all odds is the most important resource derived from the national forests. Advertising of plans for huge irrigation developments in the post-war period by the Federal Reclamation Service, and consideration of water projects by the people of every state in the region and practically every community, are producing a consciousness of the role played by the national forest lands in the economy of the region and of the need for continued and expanded influence research.

Evidence of this growing interest has been manifest in numerous calls upon the Station staff from various groups for discussions of watershed management problems. Following the Chief's report on the relation of national forests to irrigation at the National Reclamation Association meeting in Denver, the Director was called upon to present the same subject at a meeting of the Institute of Irrigation held in connection with the regional meeting of the American Farm Bureau in Idaho Falls last spring and before the Rocky Mountain Section of the Society of American Foresters in Denver. Recently the Forest Service was asked to participate in a conference of research workers on irrigation and drainage and to add its program of influence research to the overall program of irrigation research that is under way in the 17 western states.

This interest is founded not only on the realization that the mountain lands produce this water supply but also upon a knowledge that destructive floods and siltation result from improper use of these lands.

Damage from floods and sedimentation already total several million dollars annually in this region alone, and is increasing by reason of continuing watershed deterioration.

The national forests are an integral part of the vast irrigation enterprise, and the Forest Service has a tremendous responsibility for reducing surface run-off and erosion from watershed areas that have become impaired, and also in developing management plans that will keep to a minimum the damage to reservoirs and other irrigation works from the floods and siltation. But before this can be assured an expanded influence research program must be inaugurated to determine the facts and principles essential to adequate watershed management programs.

Flash Fuel Fire Studies are Needed

The fire control problem is becoming increasingly difficult each year in this region because of an increase in the number and extent of flash fuel fires which originate on valley and foothill ranges and spread rapidly into the brush and forest stands on the steep watershed lands. A major factor contributing to the mounting fire hazard has been a radical change in the fuel type on the range lands due to invasion by the highly inflammable downy chess grass.

This grass dries early in the spring and when dry it burns quickly. Fires in this grass spread rapidly--often erratically--into adjacent heavier fuel types where they burn with greater heat and cause still more damage. Downy chess grass soon invades the new burns, thus preventing or retarding recovery of native vegetation and augmenting the fire hazard for future years.

There is a rapidly growing consciousness of the need for controlling flash fuel fires and for the basic information necessary to achieve that end. All are looking to the Forest Service for leadership.

The Regional Office is most anxious that we undertake a program of fire research studies. They assisted us in preparing recommendations for such a program which were submitted to the Chief late in the year. We concur in the need for undertaking this new effort.

Big Game Range

Unsatisfactory conditions continue to prevail on many of the big game ranges within the Region. Arbitrary reductions in the numbers of deer have brought partial relief to some of the seriously congested ranges in Utah, but progress has been slow. Satisfactory management of big game ranges will never be achieved until more knowledge of big game habitat requirements is acquired.

The Station cooperated in an effort to acquire more knowledge of big game range several years ago when a preliminary study was initiated on the winter deer range near Fillmore in cooperation with the State Fish

and Game Commission, the Fish and Wildlife Service, and the Grazing Service. This effort was thwarted when a fire destroyed the range.

Interest in renewing research in this field has grown. During the past year representatives of the several Federal and State agencies concerned with the problem held a series of conferences and field trips for the purpose of outlining the specific research needs. This effort should be followed up with a view toward getting a comprehensive program of research under way in the immediate future.

Post-War Planning

Post-war planning continued to be an important activity in the Station during the past year. We were called upon for council in settling agricultural labor problems and for assistance in setting war-food production goals and in developing programs for the post-war improvement of agricultural and forest and range land resources. We also extended considerable assistance to the Region in the development of their post-war plans for watershed improvements on the national forests and collaborated with them in the preparation of statements for inclusion in Reclamation's comprehensive reports on the Colorado River, the Bonneville Lake, the Lahontan Lake, and the Columbia River drainage basins.

Much of the planning work done thus far represents a discharging of responsibilities which came to the Station from outside. It is expected that demands for assistance from outside sources will be less during the coming year. On the other hand, we continue to be faced with a tremendous in-station planning job.

In the foregoing sections of this report, brief descriptions were given of a partial array of many wildland problems on which further research is needed. The initiation of all or much of this research in the immediate future as a basis for sound action programs during the post-war period would seem to be good business. Research, however, cannot be carried on without funds and personnel, nor can studies be undertaken effectively without detailed problem analyses and blueprint plans.

With our limited staff, we have been able thus far to do no more than trace the outlines of the kind of studies which are needed to give answers in the several fields of inquiry. Preparation of problem analyses and detailed study plans for carrying out the many projects needing to be investigated would require the time of our entire staff to the exclusion of practically all other activity. We do not propose to follow such a course. Instead, pending the availability of special funds for planning purposes, we propose to restrict our planning activities during the coming year to the development of short-form problem analyses for each of the major and minor functional projects.

PART II. DIVISION CHIEF'S REPORT

A. RANGE RESEARCH

George Stewart

Range research during 1944 stressed a few phases related to the war effort as being urgent at present, such as condition and trend of range, sagebrush eradication, management of cheatgrass ranges, reseeding, and grazing management of reseeded ranges to establish the principles of good management on large areas now reseeded and to be reseeded in the near future. Conflict in range use between big game and domestic livestock is so acute that an effort is being made to get an adequate study under way.

Preparation of manuscripts also has been emphasized. One Farmers' Bulletin has appeared, a prospective bulletin submitted to Washington, and two others are well along toward manuscripts. Approximately 20 journal and short papers have appeared and not less than a dozen others are in various stages of development that will lead to publication.

Spring-Fall Range

Program, 1944

Removal of sagebrush by fire or mechanical means, determination of the principles of grazing management on spring-fall ranges, and making such information available as will provide a basis for range improvement, have received major attention.

Farmers' Bulletin 1948 which was completed in 1943 appeared early in 1944 under the heading "Sagebrush Burning--Good and Bad," by Pechanec and Stewart. A popular article appeared as Parts I and II in the NATIONAL WOOL GROWER for June and July 1944 under the heading, "Improving Sagebrush Ranges by Planned Burning." The study on sagebrush eradication begun in 1943 was continued in 1944 and a mimeographed progress report issued as "Eradication of Big Sagebrush (Artemisia tridentata)," Research Paper 10, by Pechanec, Plummer, Robertson, and Hull. Field work at the U. S. Sheep Experiment Station was just active enough to preserve the long-time records and the vegetational status of the pastures. A proposed Farmers' Bulletin "Grazing Idaho Spring-Fall Sheep Ranges," by Pechanec and Stewart was written, reviewed at the station, revised, and submitted to Washington in January 1945. Data regarding cheatgrass range were actively gathered during 1944 by Hull and Pechanec. A limited amount of time has been devoted to giving information and personal encouragement to ranchers interested in improving forage production on their own property.

Some useful contributions from this project are presented in the following paragraphs:

Grazing experiments over a period of years at the U. S. Sheep Experiment Station and close observation of range grazing on the Snake River Plains of Idaho have established a number of feasible, practicable, and valuable principles in management of spring-fall sagebrush ranges. Chief among the principles established are: (1) On the average, and allowing for unfavorable seasons, 40 to 60 percent of the current forage growth must be left on the grcund at the end of the grazing season to maintain plant vigor. (2) Where fall as well as spring grazing is to take place on a range, part of the spring growth must be left for fall use as summer and fall growth are adequate only about once in 6 years. (3) Starting grazing after range readiness and avoidance of heavy use during the critical periods of growth of the plant species are important. (4) Deferment of spring grazing is often a valuable means of providing a seed crop for natural revegetation. (5) Rotation of spring grazing by dividing the spring range into three or four parts and rotating the time of spring at which each is grazed may be a highly important means of range improvement. (6) Removal of sagebrush and suitable management thereafter is a highly effective means of range improvement. (7) Open herding, hauling water where needed, and use of bedgrounds for not to exceed 2 or 3 consecutive nights need constant attention in handling sheep. (8) Stockmen must learn to recognize range trend and condition, especially evidences of downward trend.

Sagebrush removal was found to be most cheaply and effectively accomplished by means of fire on areas suitable for controlled burning. Sagebrush can be removed from rocky areas by no other feasible method and the percentage mortality of sagebrush is usually higher than with removal by other methods. Perennial grasses are usually little damaged and where reseeding is to be practiced the seedbed is not over loose as it is likely to be after plowing. Wheatland plowing is a favored mechanical means because of moderate cost, effectiveness, and moderately good seedbed. It kills many of the native grasses, however, as well as sagebrush. Railing comes next because of its relatively low cost, fairly high kill of sagebrush, not injuring native grasses, and leaving a reasonably firm seedbed. Sagebrush eradication work should be done before sagebrush seed is mature enough to reproduce, otherwise the land will be fully reseeded to sagebrush. After sagebrush removal, all grazing should be eliminated for a year whether the area is to be reseeded or allowed to revegetate naturally. Thereafter grazing should be moderate.

The great need for a means of detecting earmarks of deterioration in range conditions led to careful observations in the sagebrush-grass vegetation of the Snake River Plains. On the gentle slopes of the nearly level Plains, where soil disturbance was less active and less serious than on steeper slopes, attention was naturally focused on the vegetation. Movement of soil by wind and water became an important indicator in advanced stages of deterioration. It has been found that, beginning with a range in good to excellent condition, the earmarks of deterioration as a result of overgrazing occur in somewhat the following order: (1) decrease in vigor of palatable perennial grasses and weeds; (2) an increase in the number and vigor of annual species; (3) a decrease in the vigor of

the most robust and somewhat less palatable grasses such as bluebunch wheatgrass; (4) the establishment of numerous sagebrush plants in the openings between older, mature sagebrush bushes; (5) the death of portions of the clumps of perennial weeds and grasses; and (6) excessive pedestaling of bunchgrasses, owing to removal of surface soil by wind or water erosion, or both. Evidence of deterioration in range vegetation was clearly apparent in the beginning of the third year in which 25 percent overstocking was practiced. At the end of the fourth year of overstocking the weights of ewes and lambs still showed no effect of overstocking. It is clear that condition of animals responds much more slowly to overuse of the range than does the condition of plants or than the losses of surface soil.

Program, 1945

The principal field work to be prosecuted during 1945 is to collect more information regarding sagebrush eradication and particularly to encourage more extensive use of the knowledge now available. Removal of sagebrush is the most important single step toward improvement of spring-fall ranges in the Intermountain region. The gathering of more data that will aid in handling cheatgrass ranges on the Snake River Plains, both for direct grazing use and as a preparatory measure for reseeding to perennial species will be continued. Records of plant development and seasonal forage yield are to be kept going at the minimum level to preserve continuity on these important phases. Grazing status of the pastures will be maintained. The manuscript on "Grazing Idaho Spring-Fall Sheep Ranges" will be pushed through the necessary revisions for publication as a Farmers' Bulletin. A shorter manuscript will be prepared by Hull and Pechanec on cheatgrass in southern Idaho for journal publication, and two or three short articles on separate phases of spring-fall range.

Summer Range

Program, 1944

The need and the demand for a means of correctly appraising how summer ranges are bearing up under grazing use are very great in the Intermountain region. Ellison, the only permanent employee assigned to summer range studies, spent most of his time on a special study of condition and trend of summer ranges, in cooperation with Croft of the Influences project. They prepared and had processed a paper and later revised the paper, aiming it for a Department bulletin. Ellison developed an inspection procedure which he presented in the field to a group of supervisors and Croft to another group. (Further information on this cooperative project is given under "Range-Watershed Condition Studies.")

Some field observations were made regarding the ecological principles that underlie management of range in central Utah. Some field work was also done on a study cooperative with the Fish and Wildlife Service regarding the effect of gophers on range forage. A rough draft manuscript on the relation to gopher activity and soil erosion has been partly

prepared. Another manuscript on the influence of microenvironment in the establishment of vegetation has been prepared but needs some revision.

The study of condition and trend on summer range has brought out the great necessity of judging more accurately than has been done in the past the actual status of forest ranges as to condition and trend in both vegetation and soil stability. In many cases judgment of use has been based on very inadequate estimates of forage utilization. Early inspection procedures also largely overlooked serious losses of surface soil which had too often injured the range by disturbing soil stability before much change in the vegetation had been observed and reported. Nor had plant indicators of downward trend been observed either with enough completeness or in sufficient detail. The whole program of grazing on forest ranges depends, for successful operation, on the ability of the rangers, supervisors, and inspectors to detect such downward trend before it is too late.

This study has not only pointed out that the status of many ranges is unsatisfactory as to condition and trend, but has helped also to develop certain basic principles in the ecology of range vegetation under grazing use. This study recognized that the soil, the vegetation, and the climate have developed a balance on mountainous ranges that is easily upset by grazing. Disturbance in balance has in many cases not been recognized until losses of surface soil have become too great to be readily corrected. Part, but not all, of this difficulty hinges on the fact that ecological processes behave differently, or at least have a different rate of development, both forward and backward, on mountainous land than on lands of gentle topography. Owing both to an inadequate background and to a new set of conditions, field observations have not been as correctly oriented and as accurately recorded as is required to give a true picture of range conditions.

Another helpful principle is making clear the vast difference in microenvironment that exists in vegetation, or at least in its fringes, from that in larger open spaces between clumps of vegetation. Grass seedlings were generally found to become established in the edges of clumps of perennial vegetation much more effectively than on bare ground between clumps. This is a highly important point in so managing summer range as to provide for natural revegetation.

Program, 1945

During 1945 the study of range condition and trend will be continued in order to fortify conclusions already reached and to permit going ahead to additional conclusions. An examination will be made of other range areas in an effort to establish indicators that point more definitely at condition and trend. These studies, designed to supplement Sampson's bulletin on succession in relation to range management will be largely concentrated on the subalpine zone of the Wasatch Plateau in central Utah.

The manuscript on "Judging Condition and Trend on Range Watersheds" will be pushed through review and revision to publication. Another manuscript on the influence of microenvironment on establishment of vegetation, aimed at ECOLOGICAL MONOGRAPHS, moved toward publication. A paper on the relation of gopher activity to soil erosion is also to be revised for one of the journals.

Winter Range

Program, 1944

Research studies on winter range for the purpose of determining how to increase forage production and how to provide more profitable management of the range and the livestock have been conducted entirely at or near the Desert Range Branch Station in southwestern Millard County, Utah. During 1944, effort has been concentrated on four phases: (1) prosecuting such highly essential parts of the long-time studies as will give them continuity and will furnish information of immediately practical value to stockmen and range administrators; (2) preparation and publication of a brief summary of findings of the winter range investigations under the heading "Winter Range Research at the Desert Branch Experimental Range," by Stewart and Hutchings (Utah Station Farm and Home Science, vol. 5, No. 1, 1944); (3) preparation of rough draft manuscript aimed at a Departmental circular regarding grazing on winter ranges; and (4) a journal article treating the subject of hauling water to sheep on the winter range. The 20 pastures and 3 herd allotments on the experimental range were grazed and data essential to continuity of studies obtained by weighing samples of sheep as they went into the pastures and as they came off and samples of sheep using one herd allotment. Essential data were taken on the forage before and after grazing, on fleece weights of marked sample sheep, on lamb crops, and on precipitation and temperature. The effects of moderate and heavy grazing on forage and animal production were compared. A rough draft of a journal article on hauling water was completed and a rough draft of a manuscript for the bulletin entitled "Grazing Management of Winter Ranges in the Intermountain Region" will be completed early in 1945.

Several important findings of winter range studies are as follows:

Over the period of about 8 years during which these studies have been in progress, pastures and range allotments that have been moderately grazed and well managed have produced from 2 to 3 times as much total forage as those heavily grazed and not so well managed. Species having the highest forage quality responded to moderate grazing and good management even more liberally, ricegrass (Oryzopsis hymenoides) and bud sagebrush (Artemisia spinescens) for example, producing more than 5 times as much forage as they did on similar ranges grazed heavily. This greater response from high-quality forages occurred because these species were in a lower state of vigor than less valuable species on account of having been grazed more heavily in the past years. On the other hand, shadscale (Atriplex confertifolia), sand dropseed (Sporobolus cryptandrus), and

small rabbitbrush (Chrysothamnus stenophyllus), species of comparatively low value, increased on heavily grazed ranges. Such species had not in the past been grazed severely enough to decrease greatly their vigor or lessen their seed production. Winterfat (Eurotia lanata) a species of intermediate palatability, showed intermediate response, increasing about 2 times as a result of moderate grazing and good management, whereas shadscale on some areas increased enough under heavy grazing to replace in a considerable degree the reduced volume of good forages. Heavy grazing in this case brought about a change from high-value to low-value species. For the range as a whole total forage production decreased as a result of heavy grazing.

The unfavorable precipitation of 1943 decreased the forage production from that of 1941 by 38 percent under moderate grazing as compared with 61 percent under heavy grazing. The unusually favorable precipitation of 1944 increased forage production in all circumstances, by 92 percent over the 1941 base figure under heavy grazing, but by 161 percent under moderate grazing. Drought is therefore much more injurious to forage production, and increased precipitation much less beneficial, on heavily grazed ranges than on moderately grazed ones.

Another point of great importance to the management of winter ranges is that the rate of range recovery after many years of heavy use, has been fully as great under a moderate degree of grazing use as under light grazing, or under complete protection. Apparently, therefore, winter range plants on comparatively gentle slopes are not benefited by unusually light use, or even by no use, in comparison with a reasonable but not excessive use. This is particularly true of the species having the highest value on the winter range--ricegrass, bud sagebrush, black sagebrush (Artemisia nova), and winterfat.

Moderate grazing and other good management practices largely eliminated the annual tumbleweed Russianthistle (Salsola kali-tenuifolia), and held in check the increase of such low-value perennial shrubs as shadscale and small rabbitbrush.

Sheep responded significantly to the better forage conditions on moderately grazed and well-managed range as compared to those on heavily grazed range. Over a period of 7 years they produced fully a pound more wool annually, and by spring had a body weight that was 12 to 20 pounds heavier than was the case with ewes grazed on ranges that had been heavily used. Death losses from malnutrition and similar causes have been practically eliminated by grazing the ranges moderately in comparison with 3 to 5 percent losses on ranges heavily used year after year. At intervals of a few years when forage and snow conditions were especially unfavorable, death losses on heavily used and poorly managed ranges have mounted to 20 to 40 percent, whereas sheep on moderately grazed ranges have suffered little from this cause. Lamb crops are 8 to 12 percent higher from ewes grazed on well managed range than from those on poorly managed ones. Lambs of ewes wintered on good range are also somewhat heavier when they are marketed the following October even though born and carried for 5 months on other ranges.

As a result of all the advantages of more and better forage and of other better management practices, ewes on good range produced heavier fleeces, higher lamb crops, lower death losses, and smaller expenses for supplemental feeding and made returns to their owners that were greater by $1.00 to $1.50 per head than did similar ewes on other ranges that were similar in all respects save that they were heavily used and not so well managed. These increased returns per ewe were great enough to have permitted owners to have reduced by 20 percent the numbers of sheep operated and still have made as good net returns as the full number now run under less satisfactory grazing management. The 20 percent reduction mentioned here is not far from the adjustment in numbers made at the Desert Station to get moderate grazing.

One of the good management practices in operation at the Desert Branch experimental range was to provide water for sheep every day without trailing the sheep to water. This necessitated hauling water to the sheep in pastures or on the range allotments when snow was not available. In cool weather ewes used somewhat less than a gallon a day. They drank more water when watered every second day than every day, and on the second day stood around several hours without grazing whereas ewes watered every day grazed consistently right up to watering time. Trampling injury to the range was several times greater when trailing to water was practiced than when water was hauled. There was noticeably more injury to the range when sheep were watered every second day instead of every day. It is significant that all grazing cooperators at the Desert Station, required to haul water to their sheep while grazing on the Station range, continued to haul after they ceased to be cooperators.

Program, 1945

During 1945 the efforts of the personnel assigned to research on winter ranges will be channeled into: (1) the continuance of grazing on pastures and herd allotments in order to preserve the sequence of data gathering and not lose the value of previous work; (2) the revision of the rough draft of the journal article on hauling water and having it published; (3) the completion and revision of the manuscript on management of winter ranges aimed at bulletin publication, and (4) after these two manuscripts the compilation of data and beginning a manuscript treating some of the major ecological principles that bear on management of winter ranges. When more funds and personnel become available to the winter-range project, several of the "backbone" studies now conducted on a minimum basis should be enlarged, the ecological studies largely suspended when the war came on ought to be rejuvenated, and a considerable mass of data regarding both the grazing at the Station and enclosures on the open range needs to be compiled and worked into reports or manuscripts.

Use of supplemental feeds, chemical analysis of forage species, preference ratings on forages, storage of food reserves by forage species, distance it is feasible for sheep or cattle to travel for water or snow, economics of hauling water, and fall forage inventories are all important problems needing emphasis in the study program.

Utilization Standards

Program, 1944

During the calendar year of 1944, five studies dealing with spring grazing of wild-hay meadows, variability in growth characteristics of forage species, and the effects of close grazing on forage production and range improvement were carried forward. (1) A study of the "Effect of Prolonged Grazing on the Yield and Quality of Forage from Wild-Hay Meadows," by Stewart and Clark appeared as a technical paper in the JOURNAL OF AMERICAN SOCIETY OF AGRONOMY (March 1944, pp. 238-248) and as a popular article in the AMERICAN CATTLE PRODUCER (June 1944). (2) A second study has been completed through to a manuscript accepted for publication in the JOURNAL OF FORESTRY, "Variability in Growth Characteristics of Forage Plants on Summer Range in Central Utah" by Clark. (3) Field work has been completed, office compilation largely completed, and a preliminary manuscript prepared treating of the relation of plant vigor and forage yield to intensity of grazing. (4) Field data were taken and partly compiled on a study of the influence of site conditions and intensity of use on forage production and plant mortality. (5) An exploratory survey was made in the mountain brush zone in central Utah showing the kind and volume of forage produced under the grazing practiced on the forest in comparison with the kind and volume produced on nine areas that have been partially or wholly protected, or reseeded and protected.

At Big Piney, Wyoming, over a 7-year period it was found that grazing wild-hay meadows in spring for 23 to 37 days longer than is normally done (about 15 days after growth starts) reduced the hay yield somewhat but improved the quality of the hay enough to make up for the difference. When the extra pasturage obtained by longer spring grazing is added to the hay, the volume of forage was increased until the total yields (hay and pasturage) were 1.79, 1.89, and 1.93 tons per acre for the meadows grazed to early, mid-, and late spring, respectively. The percentage contents of protein in the hay were 8.13, 8.25, and 9.05 from the meadows grazed to early, mid-, and late spring. This gave an acre yield of protein that was 20 percent higher on the meadow grazed to late spring than on the one grazed only in early spring. It was also found that after wild-hay passed the flowering stage it decreased rapidly in percentage of protein and became woody. Since spring ranges are generally overused in the Intermountain region, the 23 to 37 days of rest they received as a result of late pasturing on wild-hay meadows was possibly as important as the greater yield and higher quality of forage on the ranch which resulted from prolonged spring grazing of wild-hay meadows.

The findings of this study proved to be of such great interest that in addition to the 300 printed reprints distributed, it took 2,500 mimeographed reprints to fill the requests for it. The copies practically all went to farmers and stockmen with the exception of a few to technicians, county agricultural agents, etc.

Plants of 17 species of grasses, 2 species of browse, and 6 of weeds, constituting the major forage on Intermountain ranges were found to vary in plant form far more than has been commonly assumed. Thousands of plants cut into inch sections and weighed by sections from top to base of the plants showed high correlation of weight within the species according to height. The divergences from mean or from modal distribution were so great, however, varying as they did up to more than 40 percent, that height x weight tables were shown to be extremely unreliable measures either of the amount of forage produced or the amount utilized. All methods, therefore, of making forage production estimations based on height of plant, or utilization methods based on stubble height are too unreliable to be made regular procedure. Repeated tests show that direct ocular estimates of volume or of weight both for inventory and for utilization are more than twice as accurate and even more easy to apply.

Intensity of grazing use on plants of common forage species on summer ranges markedly influenced the height of plants and their forage production for the next year and in many cases for the next two years. Moderate utilization, that is, use not exceeding 50 percent of current growth, did not reduce height or yield and in many cases stimulated growth as measured in height, number of flower stalks, and time required to reach given stages of development. Grazing removal of 70 to 80 percent and of 95 to 100 percent, however, reduced height by 6 to 20 percent and by 25 to 33 percent, respectively, in the first year after treatment. A year later, but with no further grazing use, the yields for plants utilized 70 to 80 percent were 70 to 87 percent as great as that of plants not grazed, whereas the yield of plants grazed 95 to 100 percent were only 32 to 55 percent as great.

On good sites having little slope (3 to 11 percent) and with forage utilized 53 to 63 percent, 16 to 24 percent of wheatgrass plants died during 3 years whereas on poor, thin soil on steep slopes (38 to 47 percent), having use 63 to 80 percent, 70 to 78 percent of the plants died. The yields of dry forage were from 674 to 1,030 pounds per acre for the first group and 250 to 262 pounds per acre for the second group.

On nine sample areas in Ephraim Canyon, Manti National Forest, that had been protected or moderately grazed or that had been reseeded, the volume of forage produced was 4.9 times as great as that on similar ranges grazed in the ordinary fashion. These ranges are being managed largely for their browse production which was 1.8 times as great on the nine restored or protected areas as on the general range. The production of weeds actually decreased, being only 0.74 as much as on the general range. The production of forage by grasses was 20.7 times as great as on the general range, showing that this class of forage increases most readily when the opportunity is afforded. On the general range with which the protected or restored sample areas were compared, forage utilization at the end of the fall grazing period has been as a 7-year average 80 to 95 percent for grasses, 75 to 85 percent for dandelion, 30 to 40 percent for nigger-head, and 40 to 60 percent for bitterbrush and true mountainmahogany. Deer later grazed these ranges in winter.

Program, 1945

The studies of wild-hay meadows and variability of forage species will be closed as the phases under study have been finished and have reached publication. Completion of the paper on plant vigor during 1945 will conclude this particular study until more funds and personnel are available. Compilation will be brought up to date on the relation of site and intensity of use to plant mortality and forage production. A preliminary paper will be prepared on the effect of range restoration and moderate use on the kind and amount of forage produced. The effect of range restoration is a suggestive exploratory study that points the way for much valuable research when funds permit.

Benmore Project

Program, 1944

The grazing study of reseeded crested wheatgrass range at Benmore, Utah, for the purpose of determining how and when to graze the large areas seeded and to be seeded in the near future, is cooperative with the Utah Agricultural Experiment Station, the Soil Conservation Service, the Bureau of Plant Industry, Soils, and Agricultural Engineering, and the Vernon Conservation District. The reseeded range is divided into twenty-seven 100-acre pastures which are to be handled in three blocks of nine pastures each. Of the 27 pastures, the stand is not as yet satisfactory on two or three, but it is improving.

The principal activity on this project in 1944 by the Intermountain Station, which by agreement is to handle the grazing study, was to graze the nine pastures in the first block during the same period in spring and fall and to utilize the forage on all nine pastures to a moderate degree in order to approximate the grazing capacity of each pasture. Members of the Vernon Conservation District furnished 203 cattle for the pastures and about 50 other cattle which grazed on unfenced sagebrush range and served as "check" animals. Grazing in these pastures extended for 10 weeks in spring from April 19 to June 29-30, and for 7 weeks in fall from October 20 to December 6. The cattle were on the national forest range from June 30 to October 19. In summer two groups of heifers were kept in other pastures to aid the Animal Husbandry department of the Utah Station to start a study of deferred breeding of young heifers. In the fall about 150 additional cattle were put in pastures that had not been grazed. The cattle were weighed into and out of the pastures for each period of grazing, after being kept in a corral overnight.

The grazing capacities of nine 100-acre pastures, as determined from the number of cattle days of grazing and the percentage utilization, were found to vary from 53 to 85 (average 71) cattle months per pasture after 25 percent of the herbage was reserved for protecting the plants. The actual grazing use from the total spring and fall grazing amounted to 55-80 (average 63.3) cattle months. Crested wheatgrass was utilized in spring to 44-69 percent (average 52.3). At the end of the fall grazing period the total utilization amounted to 48-73 percent (average 61 percent) for crested wheatgrass and 9-17 percent (average 13.4) for cheatgrass.

While 52.3 percent of crested wheatgrass was being taken in spring, cheatgrass was taken only 3.5 percent, western wheatgrass 33.2 percent, rabbitbrush 0, and Crepis species 78 percent. Crested wheatgrass was ready for grazing April 19 but cheatgrass had only started. On May 9, 20 days later, the leaves of 50 random plants of crested wheatgrass were 7.8 inches long and those of 50 plants of cheatgrass 1.7 inches long, which at that time were not touched by cattle.

During the spring period of grazing, 203 head of cattle in pastures gained 123 pounds per head in 67 days, or 1.83 pounds per day, as compared with 75 pounds, or 1.1 pounds per day, for checks on unseeded sagebrush ranges. For 112 days in summer 57 head of heifers in the pastures gained 1.2 pounds per day--gaining more than 3 pounds per day in July, about 0.9 pound in August, and about 0.45 pound in September and the first half of October, and losing about a half pound per day from October 19 to December 6. During this late fall period, more of the 125 cows that were marked and weighed individually lost around 0.4 pound per day whereas calves gained 0.8 to 0.9 pound a day.

Program, 1945

In 1945 the grazing capacities will be determined for the nine pastures in the second block, and in 1946 for those in the third block. The moderate grazing part of the following treatment design will be initiated on the nine pastures in the first block, whose grazing capacities were determined in 1944:

Design of Grazing Experiments at Benmore

Treatment No.	Spring Use 1944	1945	1946	Intensity	Fall Use Intensity
I. Rotation Grazing					
1	Early	Mid	Late	*L, M, H	Moderate
2	Mid	Late	Early	L, M, H	Moderate
3	Late	Early	Mid	L, M, H	Moderate
II. Continual - year after year					
4	All spring - early to end			L, M, H	Moderate
5	10 days later to end			L, M, H	Moderate
6	20 days later to end			L, M, H	Moderate
III. Continual - year after year					
7	All spring to end			L, M, H	Heavy
8	10 days later to end			L, M, H	Heavy
9	20 days later to end			L, M, H	Heavy

*L = light utilization of forage
M = moderate " " "
H = heavy " " "

In 1946 and 1947 the heavy and light grazing treatments of the grazing design will be started after grazing capacities of the pastures have been determined. Data from the work done in 1944 have been compiled and a progress report prepared.

ARTIFICIAL REVEGETATION

Investigations in range reseeding are conducted for the purpose of determining the most suitable forage species and the most effective methods of restoring forage stands on large areas of range land which are producing much less forage than they are capable of doing. It is necessary also to make such information as has been gathered available to agencies and stockmen who can use it.

Program, 1944

Reseeding personnel, Robertson for Nevada, Hull for Idaho, and Plummer for Utah, cooperated with Pechanec of the spring-fall range project in field observations and in preparing the manuscript on "Eradication of Big Sagebrush (Artemisia tridentata)" by Pechanec, Plummer, Robertson, and Hull (Research Paper 10, 23 pp.). Hull wrote "Regrassing Southern Idaho Range Lands," which was published by the University of Idaho as Extension Bulletin 146. He also produced three short articles--one each in the JOURNAL OF AGRONOMY (April 1944), the AMERICAN CATTLE PRODUCER (Idaho ed. April 1944), and the NATIONAL WOOL GROWER (September 1944)--on how to reseed ranges and make use of reseeded areas. Plummer prepared a mimeographed paper comparing the grazing capacity of rye with that of crested wheatgrass (Research Paper 9), and one regarding seeding in aspen stands (Research Paper 10). Robertson published "Sagebrush Destroyer," in IMPLEMENT AND TRACTOR (June 17, 1944), and "An Efficient Method of Broadcasting," (Research Paper 8). Stewart had a short article on smooth bromegrass in the NATIONAL WOOL GROWER (November 1944).

Field work has been active at the level of one man each for Nevada, Idaho, and Utah. Data taken in the field on plantings have been limited to the phases essential to preserving continuity of long-time projects. South of Wells, Nevada, an 800-acre seeding project has been developed in cooperation with the Humboldt National Forest, the Grazing Service, and local stockmen. This project will not only furnish valuable data in regard to developing and handling large areas of reseeded range, but will serve as a demonstration for stockmen. In Idaho, studies of reseeding on cheatgrass ranges and in loose granitic soils were emphasized. Several large plantings are under study in Idaho and also in Utah, where studies, formerly concentrated on sagebrush ranges, are now getting under way in the mountain brush zone. As a beginning a small area of mountain brush with intermixed sage was removed by experimental burning preparatory to reseeding. A trial of singeing junipers with a gasoline torch has also been made as an aid in establishing reseeded forage species in juniper woodlands.

The earlier experimental plantings are now mature enough to show what may be accomplished by range reseeding, including the volume and quality of forage produced. Cooperation is active with the Grazing Service, particularly in Nevada and Idaho, with the Soil Conservation Service, particularly in Utah, with the Idaho Experiment Stations and Extension Services in all three states, and with some of the progressive stockmen.

Stewart attended the western-wide Forest Service meeting on Range Methods and Techniques at Denver, December 4-16, presented a paper under the heading "Fundamental Principles of Range Reseeding," and served as a member of the Reseeding Committee at that meeting.

Artificial reseeding studies have advanced to a stage that enables a reliable "action" program for reseeding on sagebrush range lands to be organized. Region 4 hopes to organize in 1945 such a program on a scale broad enough to bring about material increases in forage production. A formulation of the established principles to guide such an effort and presented at the Denver meeting covered such points as (1) choosing the most suitable lands in areas where the need is great, (2) the need for reducing competition of native species or of annuals, (3) use of species which are best adapted, and (4) the principles of how, when, and where to reseed. Reseeding is now recognized to be one of the major, if not the major means of making a rapid increase in range forage production. For example, in Utah during 1943 approximately 100,000 acres of range lands were seeded, two-thirds by stockmen, and in 1944 a somewhat similar area, and preparations are under way for continuing the program. In Idaho, reseeding is also definitely in the "action" stage, both on the part of public agencies and of individual stockmen. The total area seeded in Idaho is not known but must be not far from 50,000 to 60,000 acres for each of 1943 and 1944.

Data taken on several hundreds of small plots and 20 or 30 large plantings show wide variations in stand and therefore in yield. In most cases, poor stands were the result of unfavorable weather conditions, mishaps in seeding, or seeding among natural stands of species that offered too severe competition. The percentage of successful seedings was around 70 percent for large-scale forest plantings. It is thought that more care with the work will increase the percentage of successful plantings. Forage yields too have been very encouraging, generally ranging from 3 to 6 times as high as that being obtained from the deteriorated natural cover. In many cases yields 8 to 10 times as great as the natural forage have been secured, and in a few cases as great as 20 or more times. It is common for forage production on reseeded areas to be from one-half to more than 1 cow-month per acre. Because of these high acre yields, reseeding on good soils on foothill ranges is likely to prove the most effective means of relieving overgrazing pressure on forest watershed ranges. On many forest areas enough land is available for reseeding to relieve in a great measure the shortage in spring and early summer forage.

Ranges reseeded with suitable species and managed at all reasonably thereafter remain in production for a long time. A few areas on the Manti Forest seeded nearly 30 years ago are still more than twice as productive as adjacent unseeded range and still control the plant cover. These areas are principally at high elevations where conditions are favorable to smooth bromegrass, which has proved more capable of withstanding long-time use than has timothy, bluebunch wheatgrass or Kentucky bluegrass.

Four species hitherto not widely used, Agropyron intermedium, A. trichophorum, A. elongatum, and Elymus junceus, have been found in preliminary trials in the valley and foothill zones to be very promising as a means of overcoming one of the great weaknesses of crested wheatgrass. Up to the present crested wheatgrass has been the sole species that has succeeded in the dry, hot sites of the valley and lower foothills where it is highly valuable and reliable. In fall, however, unless fall rains bring fresh growth, the dry flowerstalks are both very unpalatable and of low nutritive value. Animals are likely to lose flesh during this period. The four new grasses have so far kept soft and green much later in the season than has crested wheatgrass, and appear to be considerably more palatable in the late fall.

Several selections of western wheatgrass, mountain brome, smooth brome, and bluebunch wheatgrass have shown themselves in preliminary trials to be 2 to 4 times as productive as others and much more productive than the unselected stock species. These differences are partly geographical, some strains being superior in one district and others elsewhere. Each major locality will likely be able to improve production noticeably by seeding strains that are most suitable for that locality.

Contrary to results in other ecological conditions, reseeding under aspen has been found to be about as successful when the seed is not covered with soil as when drilling or raking or dragging is practiced to cover it. Time of seeding, however, is limited to 3 or 4 weeks just before, during, or immediately after the aspens shed their leaves. The aspen leaves in this case cover the seed, conserve moisture, and serve the same purpose as a covering of soil. Not only has this practice been tested on a plot basis, but it has been successfully applied on several forest plantings of which records have been obtained from two areas, one of 300 acres and another of nearly 400 acres. Various parts of both these areas, after several years, are yielding from one-half to 2 cow months per acre. Smooth bromegrass has been most commonly used for seeding in aspen, although tall oatgrass, orchardgrass, timothy, and several other species do well. It looks feasible to seed aspen areas of the Intermountain region by distributing seed by means of airplane. The method should be tested on a sizable scale.

Destroying annual weeds such as tarweed and knotweed before they ripen seed has been found a means of reducing competition until stands of reseeded species can be established. Late summer cultivation was found of little or no avail, as the seeds of the annual weeds were all mature and

germinated and grew faster than grass seedlings. Disking, plowing, or surface cultivating after the weeds were started but ahead of flowering, reduced the stands of weeds and enabled the grasses to get started. When established, grasses suited to the conditions were able to hold their own against annuals.

In Nevada particularly, but also in other parts of the region where the fall season is very dry, late fall seeding has proved more successful than early fall seeding. Data from all parts of the region favor good covering of the seed with soil, but at distinctly shallow depths of less than an inch.

It was found that a 45-horsepower D-5 "Cat" tractor could pull two 23-disk wheatland plows in plowing moderately heavy stands of sagebrush. About 5 to 10 additional horsepower on the tractor would, however, have been desirable.

Program, 1945

Reseeding research, which for the past 8 years has been concentrated on species suitability and methods of seeding in the sagebrush zone, will be strengthened in the zones and sites on which merely exploratory studies have so far been made. The revised effort will deal principally with sites occupied by oak and maple, thick mountain brush, juniper, mountain meadows, or flats now largely in dandelion, tarweed, knotweed, or Wyethia. Steep south exposures, loose granitic soils as in parts of Idaho, and dry or sandy areas of Nevada will also receive more concentrated attention. Effort must be continued in the sagebrush zone, however, to preserve continuity of studies started previously and to round out information now available in broad form.

The grazing of reseeded areas that are established needs also study as to how much forage is produced and how best to manage the grazing. It is planned that the major part of such a study should be conducted on the Benmore cooperative project. Observations from other types of soil, from other sorts of moisture conditions, and from more sloping land will make valuable contributions as to how to handle grazing on reseeded areas.

A new study will be undertaken to determine the characteristics of vegetation and soil, which together with precipitation may be used to describe and classify sites. The aim will be to set up a group of descriptive check lists or other lists of qualities that will permit a rough grading of sites as to stability and potential productivity.

Studies now going on reseeding in cheatgrass stands and on loose granitic soils in Idaho will be greatly strengthened. New exploratory studies will be started on high mountain ranges, in the salt-desert shrub zone, and in methods of removal of heavy mountain brush.

Several publications are planned for 1945, the major one of which is a Farmers' Bulletin on the findings of reseeding research since Farmers' Bulletin 1823 came out in 1939. Several journal papers under way will be completed, as follows: (1) Influence of closed communities of sagebrush and cheatgrass on reseeding; (2) cheatgrass as a range and reseeding problem in southern Idaho; (3) the status of range reseeding investigations in the Intermountain region; (4) productivity of old reseedings; (5) reseeding on mountainous areas occupied by tarweed and knotweed; (6) germination and emergence of Indian ricegrass; (7) big-scale seeding on sagebrush ranges in Nevada; (8) time and depth of reseeding range grasses; and (9) a series of short articles on major species suitable for reseeding such as orchardgrass, tall oatgrass, western wheatgrass, big bluegrass, Russian wildrye, timothy, and bulbous bluegrass.

BIG GAME RANGE MANAGEMENT

Big game studies were begun on a "shoestring" so far as funds are concerned in 1940 to determine, if possible, the nature and degree of the conflict for forage between the domestic livestock of Utah and some 200,000 deer largely the result of a rapid increase since about 1920. What deer consume at different seasons of the year and under different degrees of stocking was, and still is, a major problem in analyzing the range situation and in providing satisfactory management. Unfortunately, the deer pasture near Fillmore, Utah on which the studies were started was burned over in August 1942, which put an end to the studies that were just well started in cooperation with the State Fish and Game Department, the Wildlife Unit of the U. S. Fish and Wildlife Service, and the U. S. Forest Service, Region 4. The conflict for forage between big game and domestic livestock is so acute and so poorly "documented" with reliable data that all technical agencies realize a new start must be made on such a basis as will provide assurance of reaching solutions.

Program, 1944

During 1944, three preliminary steps were made in big-game studies, as follows:

(1) Hutchings analyzed the data on range use from the Fillmore deer pasture, prepared, and distributed to cooperators a typed progress report on "Studies of Range Use by Mule Deer." The Fish and Wildlife Service had already prepared a report on deer diet, weight, fawn crop, and general behavior of deer in the pasture.

(2) A committee of six, representing the Utah State Fish and Game Department, Utah Agricultural College, U. S. Fish and Wildlife Service, U.S. Grazing Service, U. S. Forest Service, Region 4, and the Intermountain Station was appointed to analyze the problems and to develop plans for procedure. The committee has not yet reached a satisfactory conclusion.

(3) August 2 to 5 a 4-day field study was made of conditions on the Fishlake National Forest where deer and cattle made joint use of the range. Besides the committee of six, Chapline of our Washington Office, and Dr. Clarence Cottam and Clifford Presnall of the Fish and Wildlife Service were on the trip and held a conference at Richfield. It was agreed that the committee should develop plans and analyze sources of possible funds. Ross Leonard, Director of the Utah Fish and Game Department, attended the conference and said his department was ready to take part in and support the project.

Analyses of the data from the deer pasture showed that deer ate grass heavily when it was fresh, up to 30 or 40 percent of their diet, but consumed only 1 to 5 percent after it was dry. Grass showed evidence of increasing on the pasture and on the Fishlake ranges where deer predominated. Several browse species preferred by deer were heavily grazed--Saskatoon serviceberry, Martin ceanothus, curlleaf and true mountain-mahogany, Stansbury cliffrose, antelope bitterbrush, and skunkbush sumac. Where the range was overstocked by deer, gambel oak, sagebrush, and juniper were taken in considerable quantities but only when the more palatable species of browse were not available or had been already grazed. As measured by pasture utilization, deer took 1.8 to 2.7 pounds, dry weight, of forage per day, principally browse and weeds except in spring.

Program, 1945

Plans for future studies will be developed and sources of funds for conducting studies will be investigated by the committee with the idea of starting another study which is adequately provided with funds and personnel to do a satisfactory job of conducting the studies and analyzing the data.

B. FOREST AND RANGE INFLUENCES

George Craddock

Influences research in 1944 continued a search for watershed management measures which will lead to a reduction of flood and sedimentation damages and to increased yield of usable stream flow from the forest and range lands of the region. As in 1943, a minimum schedule of hydrologic records was maintained at two branch stations in Utah to strengthen the basis for long-range studies. Also, analyses were made of previously accumulated data from which some new information of immediate usefulness in both the soil stability and stream flow aspects of watershed management was obtained.

Soil Stability

Program, 1944

A large share of the year's effort was devoted to the development of reports on studies aimed at reducing or minimizing flood and sedimentation damages which are caused primarily by induced surface run-off and accelerated erosion. Three reports in this field were completed for publication.

A joint range-influences study of methods for determining the condition and trend of range-watershed lands was brought to completion during the year with the development of a report, "Judging Condition and Trend of Range-Watersheds," for a Department Miscellaneous Publication. This report enunciates the objectives of range-watershed management, clarifies the important ecological processes involved, describes the indicators of plant and soil responses, and outlines a procedure for utilizing these concepts and indicators in judging range-watershed lands. The final draft was developed from a tentative report which was submitted to all field officers in the region earlier in the year for their review and trial.

The concepts and procedures embodied in this report constitute a new and urgently needed working tool for managers of range-watershed lands. It has become increasingly clear in recent years that destructive floods and reduced forage production have occurred in many places largely because evidence of the deterioration of the plant-soil mantle was not recognized soon enough for the application of relatively simple and inexpensive remedial measures. Application of the new inspection procedures--by facilitating a more accurate determination of range watershed condition and trend and of needs for corrective measures--is expected to lead not only to increased range forage productivity, but also to a marked reduction in the frequency and severity of damaging floods.

The surface run-off potentials of nine important plant-soil complexes found on the watershed lands of the Sevier Lake drainage basin were reported in an article "Surface Run-off Potentials of Some Utah Range Watershed Lands," submitted for publication in the JOURNAL OF FORESTRY. This article explains how flood-producing surface run-off caused by high intensity summer rainfall can be prevented or at least greatly reduced by restoring range forage cover to a normal density. The potentialities for the effective reduction of flood and sedimentation damages by application of improved grazing practices are understandable when it is considered that most of the destructive run-off in this region arises on deteriorated range-watershed lands. This article also makes available the specific infiltration capacities of several plant-soil complexes and the average volume, duration, intensity, and frequency characteristics of summer rainfall in central Utah for use in the hydrologic analyses of other areas.

A popular article "Centerville--A Pattern for Progress," describing how the citizens of Centerville, Utah solved their flood protection and numerous other community problems through cooperative action of its citizenry, was published in the UTAH FARMER. This community began its program of self-betterment years ago by acquiring title to the headwater lands of Centerville Creek drainage basin from which their water supply is derived and by regulating the grazing use of those lands on a conservative basis. Centerville has been unharmed by floods. Adjoining communities learned the wisdom of the action taken by the people of Centerville only after they suffered severe flood damage. This article has been widely circulated in the region and should stimulate comparable local efforts toward improved watershed management in many other communities.

Stream Flow

Another portion of the year's effort was spent on analyses of data on stream flow and water loss relations with a view toward determining means of increasing usable water yields. Reports were prepared on three phases of stream flow and new data were obtained on evapo-transpiration losses along stream channels.

A detailed report "Some Recharge and Discharge Phenomena of North- and South-Facing Watershed Lands in the Wasatch Mountains," was submitted for publication in AMERICAN GEOPHYSICAL UNION TRANSACTIONS. This study revealed that south-facing slopes yielded about one-third of the annual precipitation whereas about one-half was yielded from the north-facing slopes. The spring rise of stream flow on both slopes did not occur until the soil mantle was recharged to field capacity. It required from 12 to 14 inches of late fall and winter precipitation to overcome the soil moisture deficit.

The recharge-ground water relations brought out in this study suggest the possibility of increasing the useful supply of stream flow by upstream water-spreading. It is known that stream flow from many small, steep drainage basins during the late fall and winter is largely wasted

because of the low demand for water and because surface reservoir construction is not feasible. Diverting and spreading this waste water on the mountain slopes during the late fall and winter would recharge the soil mantle in advance of the snow melting period. More of the water accumulated in the winter snow mantle therefore would be directly available for stream flow in the spring and summer when it is most needed. Further study is needed to develop water-spreading systems to accomplish this end.

A report of a study "Evaporation from Snow," was published in the BULLETIN of the AMERICAN METEOROLOGICAL SOCIETY. This study revealed that water losses due to evaporation from snow probably total as much as 3 or 4 inches during the winter season. This constitutes a loss of about 10 percent of the annual precipitation on most of the watershed lands. The study also showed that daily water losses from sites protected from wind movement were 50 percent less than on areas exposed to free air movement. More tests are needed to determine how evaporation losses can be reduced on a comparable scale by intensive treatment of the forest and range cover. Such a study holds great possibilities because any reduction in evaporation from snow in this region in most cases will result in an equal and direct increase in ground water yield.

A note, "Snow Melting and Evaporation," based on a preliminary study, was published in SCIENCE. This study revealed that daily snow-melting rates were reduced one-third when the snow mantle was shaded and by three-fourths when the site was protected from air movement as well as shading. Shading and control of wind movement were accomplished by covered frames. Further studies are needed to determine if comparable effects can be achieved by treatment of the vegetation. If successful, the delayed release of water from the snow mantle should materially prolong the recession of spring stream flow and make increased quantities of water available during the critical summer months.

Records Maintenance

Financial assistance from the Region made possible the continuation of a minimum schedule of records at the Wasatch and the Great Basin Branch Stations. Stream flow records were obtained on 26 experimental watersheds of from 10 to 14,000 acres in size. Surface run-off and erosion records were obtained from 16 small plots and soil moisture records to a depth of 6 feet were obtained from two soil pits. In addition, climatological records were obtained from a skeleton network at each of the two branch stations. The records from the untreated experimental watersheds will serve as a basis for evaluating the effects of treatments scheduled for future application. Incidental measurements of evaporation along a densely vegetated stream channel also were obtained during the year as a part of an exploratory study of evapo-transpiration losses from riparian vegetation.

Program, 1945

The 1944 accomplishments when added to previously accumulated knowledge not only fortify the importance of watershed management in this region, but also clarify the direction of future influences research. There is no question but what flood and sedimentation damages can be materially reduced by restoring and maintaining normal conditions of cover and soil on the watershed lands. There remains, however, the major problems of determining the maximum degree of beneficial use which can be made of the forest and range resources on the many different soils of the region without impairing the watershed protection function, and the development of procedures for the accurate appraisal of observable responses to treatment in the plant and soil mantle. A second major field of further research is a follow-up on the possibilities of increasing useful stream flow by headwater spreading of waste run-off and by cultural treatments to reduce evapo-transpiration losses and to delay snow melting.

Solution of these problems will require much new research beyond that which is feasible with present funds and personnel, although considerable progress can be made in this direction with the present means. To this end the following program will be followed during 1945.

1. Maintenance of long-term studies. A minimum schedule of climatological and hydrological records will be maintained at the Great Basin and Wasatch Branch Stations for the purpose of continuing five long-range studies. These are as follows:

(a) Effect of grazing on surface run-off and erosion in the A-B Experimental Watersheds at Great Basin Branch Station.

(b) Effect of upstream treatment on stream flow in several sub-basins of Ephraim Creek.

(c) Effect of grazing on stream flow in sub-basins of Farmington Creek.

(d) Effect of cover type on surface run-off and erosion at Wasatch Branch.

(e) Effect of cover type and exposure on water supply and stream flow forecasting.

2. Infiltrometer study. A study will be made of the surface run-off, erosion and infiltration characteristics of the herbaceous-cover limestone-soil range-watershed complex in the immediate vicinity of the Alpine substation by means of Type F infiltrometer. This study will overcome deficiencies in the 30-year A-B watershed experiment regarding the specific effects of changed site conditions due to trampling and clipping, seasonal phenomena, and storm occurrence on surface run-off and erosion and will provide basic data for a comparison study of soil indicators.

3. Soil indicator study. A study will be made of soil characteristics within the herbaceous-cover limestone-soil complex to develop methods of using soil and other site indicators for determining condition and trend of range watershed lands. This study, like the infiltrometer study, will supplement the A-B watershed study and previous work on the studies of condition and trend.

4. Publications. Several reports are scheduled for completion in the coming year based on data already available and the new information to be obtained from the infiltrometer study. These are as follows:

(a) A technical bulletin, "The influence of herbaceous vegetation and grazing on surface run-off and erosion" by Craddock and Croft as a follow-up to Tech. Bul. 220.

(b) A Misc. Publication, "Judging condition and trend of range-watersheds," by Ellison, Croft, and Bailey.

(c) A paper for A.G.U., "Some factors in forecasting run-off," by Croft.

(d) A Jour. Forestry paper, "Changes in run-off variability," by Croft.

(e) An A.G.U. paper, "Influence of natural and induced site changes on surface run-off, erosion, and infiltration," by Craddock.

(f) An A.G.U. paper, "Water losses by transpiration and by evaporation from stream surfaces," by Croft.

(g) A Utah Farmer paper, "Waterspreading methods," by Croft.

5. Short-term jobs. Several short-term jobs will be undertaken to the extent time permits as follows:

(a) Development of a brief form problem analysis.

(b) Technical aid to the Region.

(c) Inspection of flooded watershed and problem areas.

Range-Watershed Condition Studies

Program, 1944

A report of the range condition and trend study begun by Ellison and Croft in the summer of 1942 was processed in mimeograph form and distributed to the field in Region 4 and to other key range men in the Intermountain Region. The report title is "Principles and Indicators for Judging Condition and Trend on High Range-Watersheds." Reasons for undertaking the the study and its broad objectives were outlined in the 1942 annual report and a preliminary statement of progress was made in the 1943 report.

Ellison spent considerable time during the summer in developing and testing various range inspection procedures after which he and Croft, in cooperation with R-4 range men, presented a form and an inspection procedure suitable for field use. Ellison reported the procedure in detail at the range techniques meeting in Denver.

Two supervisors training schools were held to try out the recommended inspection procedure and to scrutinize the management objectives and indicators presented in the condition and trend report which had been sent to the field in early summer. One school was conducted on the Manti Forest with Ellison participating and another on the Boise with Croft participating.

In response to a request made at the time the condition and trend paper was transmitted to the field, that its recommendations be given critical consideration out on the range, reports have been received from practically all forests in the Region and from some outside. Largely as a result of favorable comments that have grown out of these field trials the paper has been rewritten with the idea that it will be published by the Department as a Miscellaneous Publication.

Presentation of the condition and trend report for publication is done with the belief that it represents a significant contribution to range-watershed management. The major features of the report are as follows:

1. Two definite management objectives are set up, both of which have wide application on mountain ranges regardless of type. The preliminary objective is balance in the range-watershed complex; in other words maintenance of a stable relationship between topography, soil, climate, vegetation, and animals so that the resource will be preserved. The other, or secondary objective, is vegetal cover of high forage value. Obviously forage, a renewable part of the range, is to be considered second in importance to soil which is not renewable, in the lifetime of man, at least.

2. It presents a framework of ecological principles essential to an understanding of the range, and to the interpretation of the indicators used in judging condition and trend in relation to the two management objectives.

3. The report discusses and evaluates also, indicators that have rather wide application in judging condition and trend of mountain range-watersheds, with particular reference to the two management objectives.

4. Finally, the report discusses a procedure for range inspection which includes tabulation of observed facts on a standard report form, and the essentials of reasoning with, and weighting, the observed facts in reaching sound conclusions as to condition and trend.

The principles and procedures presented in the report have very definite application to the management of wild mountain lands, both for water yield and forage production, which will be discussed in the Influences and Summer Range reports.

Program, 1945

Plans are going forward to process the report as a Miscellaneous Publication under the title "Judging Condition and Trend of Range-Watersheds." If approved, it is hoped the publication will be available for distribution by summer to range managers and livestock men in the Intermountain region. Ellison and Croft will continue to cooperate with the Regional Office in conducting training schools for supervisors aimed at putting into practice the procedures recommended in the report.

C. FOREST AND RANGE ECONOMICS

George Craddock

Economics work at the Station during the past year included assistance in furthering the Department's war-food production program, further development of post-war plans, and an exploratory study of the economic aspects of watershed management.

Program, 1944

The Station bore a major share of the effort of developing the land management phases of a Preliminary Agricultural Post-War Planning Report for Utah. This report carried a strong statement of the need for adjusting use of the range to grazing capacity but the effectiveness of the recommendations toward that end were largely obscured by the inclusion elsewhere in the report of goals for livestock numbers at essentially the present excessively high levels. Further work with the planning group resulted in the preparation of supplemental reports in which a more realistic picture of the range and livestock production situation was presented in the form of lowered goals for range livestock numbers and recommendations for range improvement. The new goals for livestock numbers and the accompanying recommendations for decreasing grazing use and improvement of the range have been widely distributed for the use of local planning groups. It is not yet possible to evaluate the effectiveness of this effort, but from the tenor of discussions at recent range livestock meetings, it appears that the dual program of conservative grazing and intensive range improvement has met with general approval.

Considerable assistance was extended to the several regional office divisions on the economic aspects of their post-war plans, particularly on those phases dealing with proposed improvements for watershed protection. In addition, the Station collaborated with the Region in the preparation of material requested by the Bureau of Reclamation for comprehensive reports on the Colorado River, the Bonneville Lake, the Lahontan Lake, and the R-4 portion of the Columbia River drainage basins.

Materials and ideas on the economic aspects of range-watershed management problems peculiar to this Region were partially assembled for preparation of a guide for planning watershed improvement programs. There is a continuing need for this guide.

Program, 1945

A three-point program is to be undertaken in 1945, as follows:

1. Continue the study of range-watershed economics and develop a guide or handbook on simple procedures for evaluating and correlating plans for range-watershed improvements.

2. Continue technical assistance on war-food production programs.

3. Continue technical assistance on post-war improvement planning.

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STATION PERSONNEL - C. Y. 1944

ADMINISTRATION

Reed W. Bailey	Director
Walter E. Mann	Adm. Asst.
Marguerite A. Israelson	Clerk
Leona H. O'Donnell	Clerk
Hazel B. Ballinger	Clerk-Steno
Irene O. Pope	Clerk-Steno

RANGE INVESTIGATIONS

Grazing Management

George Stewart	Forest Ecologist
Lincoln Ellison	Range Examiner
Joseph F. Pechanec	Forest Ecologist
Selar S. Hutchings	Forest Ecologist
Ira Clark	Conservationist
Earl L. Yersin	Agricultural Aid
Paul E. Hansen	Agricultural Aid

Artificial Reseeding

George Stewart	Forest Ecologist
Alvin C. Hull, Jr.	Forest Ecologist
A. Perry Plummer	Forest Ecologist
Joseph H. Robertson	Forest Ecologist

FOREST AND RANGE ECONOMICS

George W. Craddock	Range Examiner

FOREST AND RANGE INFLUENCES

George W. Craddock	Range Examiner
A. Russell Croft	Conservationist
Alden Blain	Agricultural Aid

FOREST AND RANGE BIOLOGY

Clarence M. Aldous	Biologist
(Cooperation Fish and Wildlife Service)	